LEACHING CHARACTERISTICS OF FLUORIDE FROM POND ASH

A THESIS SUBMITTED IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

MINING ENGINEERING

By

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NATIONAL INSTITUTE OF TECHNOLOGY
ROURKELA-769008
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Under the Guidance of

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CERTIFICATE

This is to certify that the thesis entitled **"Leaching characteristics of fluoride from pond ash"** submitted by **Gayadhar mallik** in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at National Institute of Technology, Rourkela(Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University/Institute for the award of any Degree or Diploma.

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ACKNOWLEDGEMENT

I wish to express my profound gratitude and indebtedness to Prof. Sk. Md. Equeenuddin, Department of Mining Engineering, N.I.T Rourkela and Head of the Department of Mining Engineering, N.I.T. Rourkela for introducing the present topic and for their inspiring guidance, constructive criticism and valuable suggestion throughout this project work.

I am thankful to Mr.M.Dildar and other staffs in Department of Mining Engineering for their assistance and help in carrying out different experiments in the laboratories. I am also thankful to HOD, Department of Metallurgical & Materials Engineering and for extending their support for carrying out experiments in their laboratories. I also extend my sincere thanks to N. R. Sahu, State Pollution Control Board, Bhubaneswar for his cooperation during collection of the samples.

Last but not the least my sincere thanks to all my friends who have patiently extended all sorts of help for accomplishing this undertaking.

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ABSTRACT

Now, more than 100 million tons of coal fly ash is produced annually in India from combustion of coal in power plants. It is expected that about 150 million tons of coal ash will be produced due to burning of coal in power plants by the year of 2015. This will require about 30,000 hectare of land for the disposal of ash. One of the biggest problems due to disposal of large quantities of coal ash is the possible leaching of different hazardous pollutants, including fluoride. A thorough investigating concerning leaching of fluoride from fly ash is much more indispensable to know the impingement of fluoride due to its leaching from fly ash to ground water as well as surface water. In this paper, short term and long term leaching studies will be carried out on pond ash, pond ash water of different thermal power plants: Rourkela Steel Plant (RSP), Rourkela; National Thermal Power Corporation (NTPC), Kaniha; National Aluminium Corporation Limited (NALCO), Angul; IB Thermal Power Station (ITPS), Banharpali. The amount of fluoride released in different experiments will be evaluated. Environmental impact of pond ash and fluoride has been discussed.

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INTRODUCTION

Annually production of fly ash is more than 150 million tonnes worldwide due to combustion of coal in thermal power stations. At least a half of this amount is disposed of by landfill, hence contributing to environmental pollution due to leaching of its toxic constituents. One of the critical constituents is fluoride which may be toxic at elevated levels in water.

Disposal of huge amounts of fly ash in landfills and surface impoundments or its re-use in construction materials is related to environmental concern. While much effort has been committed to the problem of leaching of heavy metals from disposal of fly ash; the release of non-metals has attracted considerably less attention. Of these, arsenic, selenium, and boron stand out as potentially harmful to both vegetation and animals.

The fluoride levels of coal fly ash change within broad limits of 0.4 - 610 µg/g (Rai, 1987). It depends on the type of coal being burnt, the particle size of the ash, and the efficiency of electrostatic precipitators.

The amount of leachable constituents of fly ash is important to estimate their availability for the biological systems. The primary objective of the present study was to examine the release of fluoride from fly ash to water under a variety of conditions.

1.1 OBJECTIVES:

- Characterization of pond ash.
- Study the behavior of fluoride and other parameters during leaching of pond ash.
- To compare the leaching behavior of fluoride and parameters of ash pond water from different pond ash samples as well as ash pond water samples.

CHAPTER 2

LITERATURE REVIEW

WHAT IS FLY ASH

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LITERATURE REVIEW

2.1 WHAT IS FLY ASH

Fly ash is one of the legion substances that can cause air, water as well as soil pollution, interrupt ecological cycles and explode environmental hazards.

The process of combustion of powdered coal in the thermal power plants gives rise fly ash and constitutes the finer particles which rise with the flue gases. Coal Ash which does not rise is named as bottom ash. The fly ash is generally captured by electrostatic precipitators or other particle filtration instrument earlier the flue gases reach the chimney of coal-fired power plants. Together with bottom ash removed from the bottom of the furnace is jointly known as coal ash.

The components of fly ash vary considerably depending upon the source and make up of coal being burned. But all fly ash includes substantial quantities of silicon dioxide (both amorphous and crystalline) and calcium oxide, both being ingredients in many coal-bearing rock strata.

Toxic constituents include the elements in quantities from trace amounts like: beryllium, arsenic, boron, chromium, cadmium, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, vanadium, and thallium. These trace elements in various quantities and during combustion process of coal they all get enriched as a result of carbon loss as carbon dioxide and trace elements get associated on the surface of ash particles due to evaporation and condensation. The characteristics of the coal used and the type of installations used for the generation of a fly ash have a direct influence on chemical and mineralogical composition of fly ash (Benito et al., 2001).

2.2 CHEMICAL COMPOSITION AND CLASSIFICATION

Fly ash solidifies when suspended in the exhaust gases and is collected by electrostatic precipitators. The particles solidify while suspended in the exhaust gases and fly ash particles are generally spherical shape and size range from 0.5 µm to 100 µm. They consist of silicon dioxide (SiO_2), which is present in two forms like: amorphous, and it is and smooth rounded; and crystalline, which is, pointed, sharp and hazardous substance; and iron oxide (Fe_2O_3), aluminums oxide (Al_2O_3). Fly ash is highly heterogeneous, consisting of a mixture of glassy particles with various crystalline phases like, mullite, quartz and iron oxides.

Fly ash contains environmental toxic elements like barium, arsenic, beryllium, cadmium, boron, chromium, copper, cobalt, fluorine, lead, manganese, nickel, selenium, strontium, vanadium, thallium and zinc

The above quantities of trace elements change according to the type of coal burnt to form fly ash. In fact, for bituminous coal, with the exception of boron, trace element quantities are similar to trace element quantities in uncontaminated soils.

Fly ashes are classified into two types by ASTM C618: Class C fly ash and Class F fly ash. The major difference between these classes of fly ash is the quantity of calcium, alumina, silica, and iron content in the fly ash. The chemical properties of the ash are largely influenced by the chemical content of the coal which is burned (i.e. lignite, bituminous, and anthracite).

The demand of coal supply by energy sector is increasing. So coal supply is subsequently required in huge amount for the energy sector, which in turn can increase the amount of fly ash production. Around 112 million tonnes of fly ash was generated in 2007 (Dhadse et al., 2008). The problem with fly ash lies in the fact that its disposal requires large quantities of land, water, and energy, its fine particles, if not managed well, by virtue of their weightlessness, can become airborne. Fly ash has occupied 65 acres of land (Chakravarthi et al., 2007). So leaching studies are important in predicting the environmental impact associated with ash pond disposal techniques (Prahraj et al., 2002). Utilization of fly ash in India is very low as compared to other coal producing countries (Table 2.1) as majority of fly ash is lying in the ash pond.

Table 2.1: Production of fly ash worldwide (Dhadse et al., 2008)

Country	Ash production (Million tonnes)	Ash Utilization %
India	112	38
China	100	45
USA	75	65
Germany	410	85
UK	15	50
Australia	10	85
Canada	6	75
France	3	85
Denmark	2	100
Italy	2	100
Netherlands	2	100

2.3 FLY ASH GENERATION

The fly ash is a fine grained, powdery particulate material that is produced from burning pulverized coal in coal-fired boiler and is carried away in the flue gas and collected by electrostatic precipitators, mechanical collection devices or bag houses such as cyclones.

Generally, three types of coal-fired boiler furnaces are used in the thermal power plants. They are called as cyclone furnaces, dry bottom boilers and wet bottom boilers. The mostly common type of coal combustion furnace is dry-bottom furnace.

About 80 percent of all the coal ash leaves the furnace when pulverized coal is burned in a dry-ash, dry-bottom boiler as fly ash entrained in the flue gas. About 50 percent of the ash is remained in the furnace when the pulverized coal is burned in a wet-bottom (or slag-tap) furnace.

Generally, coal-fired power and steam generating plants produces Fly ash. After coal is pulverized, it is blown with air into the boiler's burning chamber. It is immediately ignites, generating heat and producing a molten mineral residue like structure. Boiler tubes extract heat from the boiler by cooling the flue gas. And causes the molten mineral residue to hardening to form ash. Coarser ash particles fall to the bottom of the combustion chamber called as bottom ash or slag. The lighter fine ash particles that remain suspended in the flue gas referred as fly ash.

Fly ash is removed by particulate emission control devices like electrostatic precipitators or filter fabric bag houses prior to exhausting the flue gas. The different methods of fly ash transfer are shown in the Figure 2.1.

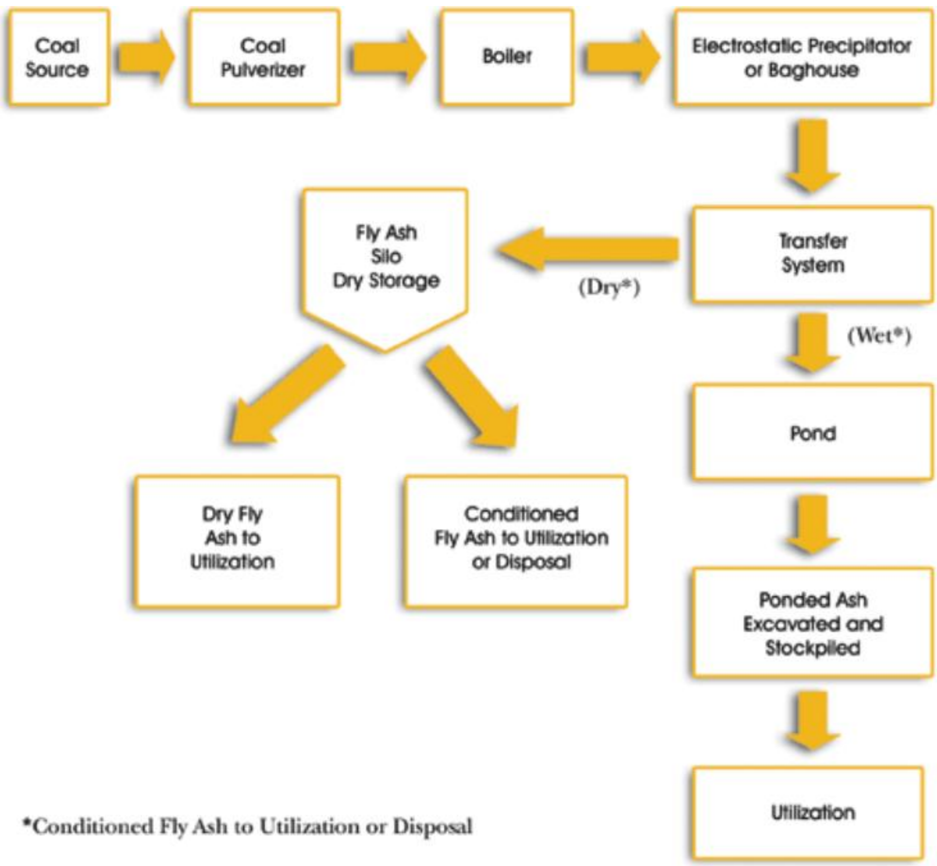

Fig 2.1: Method of fly ash transfer (http://www.fhwa.dot.gov/pavement/recycling/fach01.cfm)

Fly ash was released into the atmosphere generally in the past, but in recent decades, pollution control equipment assigned that it is to be captured prior to release to the atmosphere. Fly ash is stored generally at coal power plants or placed in landfills in the US. At present most of the fly ash is being dumped in India. The disposal of fly ash is a serious hazard. For dumping about 14000 hectare of land has already been used In India. Other thousands of hectare would be required in future for disposal. In India, coal (lignite) based thermal power plants account for more than 55% of the electricity capacity and 65% of electricity generation. The ash content of the coal that has been used at the thermal power plants ranges from 30-40% with the average ash content nearly about 35%. Since low ash and high grade coal is reserved for metallurgical industries; the thermal power stations have to utilize high ash, low grade coal. In the thermal power plant, ash generation has increased from about 40 million tonnes during 1993-1994 to 120 million tonnes during 2005-06. It is expected that there will be used in the range of 175 million tonnes per year by 2012, for the reason of the proposal to double the power generation. Coupled with this, the deteriorating quality (increasing ash quantity) of coal is expected to aggravate the situation.

Within three-four years, another approximately 78,000 mw of new power generation capacity is expected to come up in the country. Out of this major portion, around 60 percent would come in the form of thermal power. Estimated generation of fly ash till 2012 would be 175 million tonnes and again it would pose a serious problem of disposal. The major consumer of fly ash is the cement industry only. Some small quantities are used for making fly ash bricks, land fill etc.

2.4 ENVIRONMENTAL IMPACT DUE TO FLY ASH

Fly ash is a very fine powder substance and it can travel far in the air. If not properly disposed, it can pollute air and water, and can cause respiratory problems when inhaled. When it settles on leaves of plants and crops in fields around the power plant, it lowers the yield.

The conventional method used to dispose of both fly ash and bottom ash by converting them into slurry for impounding in ash ponds around the thermal plants. This method causes long term problems. The problems caused due to fly ash dumping are shown in Figure 2.2.

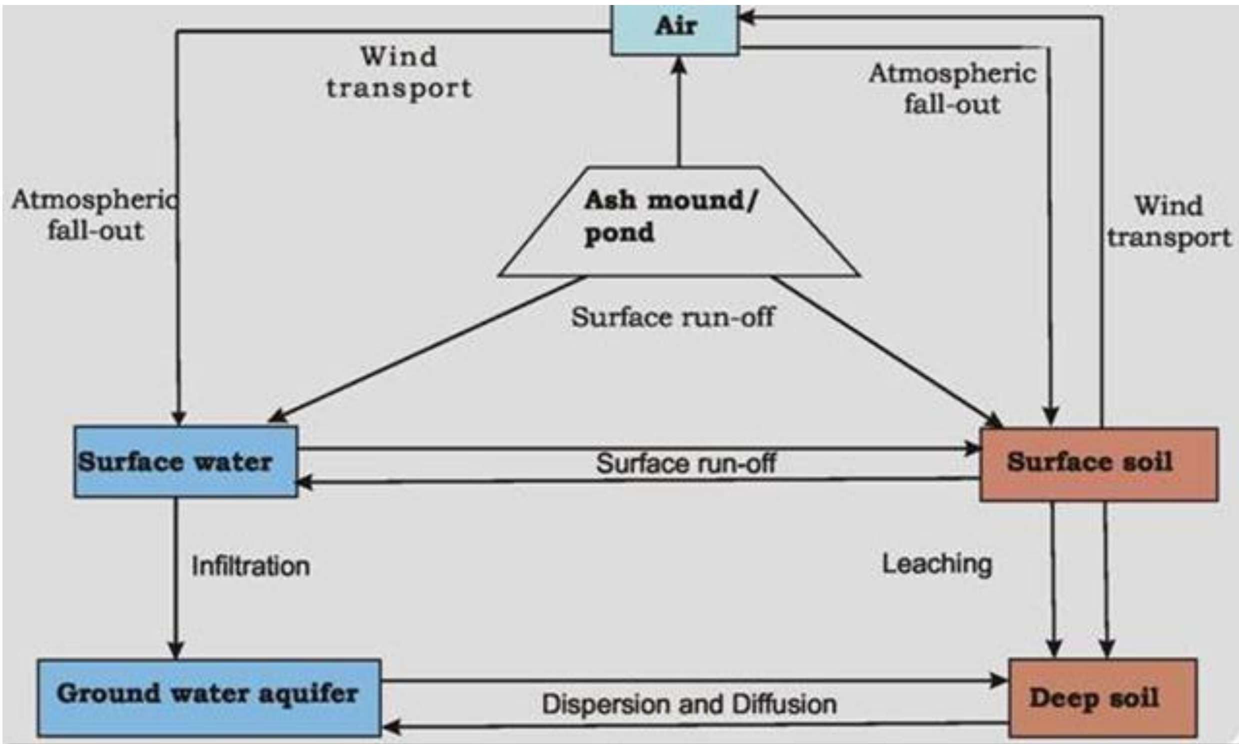

Fig 2.2: Dumping of fly ash leads to pollution of air, land and water
(http://flyashbricksinfo.com/How-fly-ash-is-hazardous.html)

2.4.1 LAND POLLUTION

Most of the fly ash and bottom ash produced is disposed on the land or in settling basins. Settling basins or ponds that receive fly ash are typically lined, but basins that receive bottom ash are unlined. Fly ash tends to leach more soluble, because it is more finely divided than bottom ash and enriched in many trace elements like arsenic, boron, chloride, fluoride, selenium; therefore, ponds containing fly ash are lined. Excess water in the fly ash ponds is typically disposed to the surface streams. Wet sites are usually located in the immediate proximity of power plants, because of the difficulties and expense of slurry transport over long distances. Bottom ash and fly ash are sometimes slurried to the same pond.

2.4.1.1 AQUATIC TOXICITY DUE TO FLY ASH

Fly ash has negatively charged surface area. Preliminary investigations have shown that its alkaline nature may mitigate acid mine drainage (AMD) by neutralizing pH and adsorbing positively charged metal ions (Jackson 1993).

The fact that heavy metals and other trace elements are associated with fly ash particles has been reported from the Glen Lyn Power plant, located in Glen Lyn, Virginia (cherry et al., 1987).

The water quality in ground water is highly variable but it can become contaminated with dry fly ash when pumped into empty coal seams filled with the ash. The dry fly ash will be much more elementally enriched than fly ash that has settled over time in a retention pond (Cherry et al., 1987). The Eco toxicological studies reported to date deal with the effects of fly ash after its release from a holding pond.

2.4.1.2 ELEVATED CONCENTRATION OF TOXIC ELEMENTS

Metal content associated with fly ash discharges to vary widely in power plants evaluated at the Savannah River Project, in South Carolina, and the Glen Lyn Power plant in Virginia (Cherry et al., 1976, 1979a, b, 1984a, b. Cherry and Guthrie 1978, Cairns and Cherry 1983 and Specht et al 1984). High aquatic concentrations on an annual basis were found released from a fly ash pond of a coal-fired fossil fuel power plant into a stream or swamp receiving system at the SRP during the 1970's (Cherry et al., 1976). These elevated elemental concentrations persisted in the water column and became incorporated into the sediment and then were bio accumulated by various benthic macro invertebrates (Cherry and Guthrie 1977, 1978, 1979; Cherry et al., 1979a, b; Guthrie and Cherry 1979a, b; Guthrie et al 1983, 1986).

Two studies have been conducted in Delhi, India, to determine the impacts of coal ash effluent on the chemical and biological properties of the river Yamuna (Waalia and Mehra, 1998a,b). The first study (Walia1998a) examined chemical changes, measuring a suit of physico-chemical parameters at two sites of upstream and downstream of large power station. The station had a total generation capacity of 225 MW, and daily used 4000 tones of bituminous coal. The station produced 1600 tons of coal combustion ash daily, 80% of which was fly ash. The ash was sluiced into a series of settling ponds. The overrun flowed into the River Yamuna. Significant differences between the sites were observed for a number of water quality parameters like conductivity, TDS, dissolved oxygen, total hardness, sulphate, and nitrate, all of which had higher values downstream of the effluent over the two year sampling period. Free carbon dioxide, total alkalinity and phosphate were significantly lower in the downstream of the effluent. No differences were observed between the two stations for pH, temperature, chloride, and nitrate.

The second study was conducted at the river Yamuna power plant site compared plankton assemblages upstream and downstream of the fly ash effluent (Walia and Mehra 1998b). Over the two year study, average phytoplankton diversity was cut down in the downstream of the effluent. The total phytoplankton in cell/litre was significantly reduced in the downstream during all seasons except for autumn of 1991. Total zooplankton numbers were reduced in the downstream of the effluent also. Rotifers and protistans were especially affected by having lower densities at the downstream sites on several occasions in the two year period. Cladocerans were similarly impacted but to a lesser extent. Species diversity indices for zooplankton were not significantly different between the two stations. While differences were observed for a number of different biological parameters investigated. This was likely due to the fact that the upstream station had elevated concentrations of a number of toxic metals.

2.4.1.3 RADIOACTIVE ELEMENTS IN COAL AND FLY ASH

Coal is largely composed of organic matter. Some trace elements in coal are naturally radioactive in nature. These radioactive elements include uranium (U), thorium (Th) and their numerous decay products including radium (Ra) and radon (Rn). These elements are less chemically toxic than other coal constituents such as arsenic, selenium, or mercury but questions have been raised concerning possible risk from radioactive radiation. Radioactive elements from fly ash may come in contact with the general public when they are disseminated in air and water.

2.5 ENVIRONMENTAL IMPACT OF FLUORIDE

2.5.1 SOIL IMPACT

Although natural fluoride concentrations in soil are commonly low (Stewart et al., 1974b, Manley et al., 1975, McLaughlin et al., 1996), the amounts and concentration in the soil solution may be sufficient to induce adverse effects (Braen and Weistein 1985). Two sets of conditions may be affected: firstly, fluoride may become available to plants and be ingested by animals; secondly, fluoride may release into surface or groundwater.

The availability of soil fluoride to plants varies with the mineralogy, pH, and organic matter content and buffering capacity of the soil (Barrow and Ellis 1996; Holford 1997; Stevens et al., 1997, 2000). For many years, soil fluoride was considered to be effectively unavailable to plants (Larsen and Widdowson 1971), and the availability of fluoride from natural soils is almost always too limited to cause disorders in grazing animals (McLaughlin et al 1996, Cronin et al ., 2000). However, fluoride reaching soils as a component of solid waste (Baars et al.,1987, Ho et al.,1989, Summers et al., 1996), as an additive in the form of sewage sludge (Davis 1980) or as an impurity in phosphate fertilizers (O'Hara and Cordes 1982, O'Hara et al.,1982a, b, McLaughlin et al.,1996, 2001, Manoharan et al.,1996, Cronin et al., 2000, Stevens et al .,2000) may be transferred to the soil solution in sufficient quantities to have adverse effects on either plants or grazing animals.

The various range of concentration of fluoride in coal and fly ash in different locations are given in the table no 2.2 and 2.3.

Table 2.2: Examples of reported fluoride content (mg/l) in coal and accompanying shale

Area	**Range of concentration (mg/l)**	**Reference**
Western USA	19-140	Gluskoter,1977, valcovic,1983
Eastern USA	50-150	Zubovic et al,1979
Western Canada	31-930	Godbeer et al,1994
Latrobe valley, Australia	4-79	Swaine, 1990,Volcanic,1983
Britain coal	≤ 0-170	Crossley, 1994
North-west china	48-149	Luo et al,2002

Table 2.3: Fluoride in fly ash

Location	**Concentration (mg/l)**	**Reference**
Netherlands	80	http://health.groups.yahoo.com/group/pfpcnews/message/134
china	114	http://health.groups.yahoo.com/group/pfpcnews/message/134
Africa	200	http://health.groups.yahoo.com/group/pfpcnews/message/134

2.5.1.1 WATER POLLUTION DUE TO FLUORIDE

Water drainage from fluoride-containing rocks and soils contain fluoride, at concentrations that range from <0.1 to 8 mg/L (Harvey 1952, Maneley et al., 1975, Wheeler and Fell 1983, Weinstein and Davison 2004). This fluoride occurs in a variety of ionic forms, and it may be available for uptake by plants or ingestion by animals to the point where fluorosis may occur.

For plants grown in solution culture, Horne and Bell (1995) observed marked differences in the growth responses of both roots and shoots of wheat and ryegrass plant to fluoride concentrations (0, 30 or 100 mg/L), pH (4.0, 4.6 or 5.6) and their interactions, with the greatest differences occurring between pH 4.0 and 4.6 at fluoride concentrations of 30 and 100 mg/L.

This example indicates that wastewater containing fluoride concentrations of 30 mg/L may affect plants immediately, and lower concentrations may lead to adverse effect if evaporation is a major component of the site water balance.

2.5.1.2 HAZARDS DUE TO FLUORIDE IN WATER

The different hazards due to fluoride in water are:

- ✓ Neurotoxic and Lowers IQ
- ✓ Causes Cancer
- ✓ Changes Bone Structure and Strength
- ✓ Causes Birth Defects and Perinatal Deaths
- ✓ Proven Ineffective
- ✓ Impairs Immune System
- ✓ Causes Acute Adverse Reactions
- ✓ Causes Initial Stages of Skeletal Fluorosis
- ✓ Increases Lead and Arsenic Exposure
- ✓ Fluoride Causes Osteoarthritis
- ✓ Contributes to the Repetitive Stress Injury
- ✓ Causes dental fluorosis in Many Children
- ✓ Affect Key Enzymes
- ✓ Affect Thyroid Function
- ✓ Causes Acute Poisonings

The various effect of fluoride concentration and their effects on human body is given in the table 2.4.

Table 2.4: fluoride concentration and their effects on human body

Sl no	**Fluoride(mg/l)**	**Effect on human body**
1	Below 0.5	Dental caries
2	0.5 to 1.0	Protection against dental caries, takes care of bone and teeth
3	1.5 to 3.0	Dental fluorosis
4	3 to 10	Skeletal fluorosis (adverse changes in bone structure)
5	10 or more	Crippling skeletal fluorosis and severe osteoclerosis

2.5.1.3 FLUORIDE IN PLANTS

For most plant species, foliage fluoride concentrations in uncontaminated environments are usually less than 10 mg/kg. Some plant species are known to accumulate relatively high concentrations of fluoride from normal soils. One of the most widely known examples is tea (*Camella sinesis*), the leaves of which may contain more than 200 mg/kg of fluoride (Weinstein and Davison 2004). There is not a single fluoride concentration above which vegetation can be considered to be contaminated with fluoride, and no single concentration above which it can be assumed that there will be adverse physiological effects on the plant. Adverse effects may be detected in some species when foliage fluoride concentrations of 1000 mg/kg (Doley 1986a). This means that surveys of foliar fluoride concentration must be interpreted with great care.

2.5.1.4 FLUORIDE IMPACT ON ANIMALS

Fluoride will accumulate in tissues of animals that have high calcium contents (Weinstein and Davison 2004), such as teeth and bones. It is generally conceded that some fluoride is beneficial for healthy animals may range between 80 and 200 mg/kg (Harvey 1952). Fluoride provided in forage, water or as mineral residues may result in accumulation of fluoride to more than 2000 mg/kg (Stewart et al., 1974a, Manley et al., 1975, Wheeler et al., 1985, Bourke and Ottaway 1998, Weinstein and Davison 2004)

Animals that eat fluorine-containing plants may accumulate large amounts of fluorine in their bodies. Fluorine primarily accumulates in bones. Consequently, animals that are exposed to high concentrations of fluorine suffer from dental decay and bone degradation. Too much fluorine can also cause the uptake of food from the paunch to decline and it can disturb the development of claws. Finally, it can cause low birth-weights.

Fluoride increases the production of free radicals in the brain, raising the possibility that it increases the risk of Alzheimer’s disease; more research is needed to clarify fluorides and biochemical effects on the brain.

Fluoride exposure could affect the pineal gland, resulting in altered melatonin production, and altered timing of sexual maturity. Down’s syndrome is a biologically plausible outcome of fluoride exposure. Because of fluoride concentration in the kidneys and renal system may be at higher risk of fluoride toxicity than most soft tissue. Fluoride appears to have the potential to initiate or promote cancers, particularly of the bone, with osteosarcoma being of particular concern.

2.5.1.5 HEALTH HAZARDS

As with many substances, the recycling and disposal of Fly ash raises concerns about its human health and ecological effects. Most health-related question about fly ash center on the inhalation of fly ash particles, ingestion of particles or dissolved trace element or direct skin contact due to wind erosion of dry fly ash. FA may cause severe health problems like asthmatic disorders, eye and skin problems. FA is a serious source of air pollution since it remains air-borne for a long period and causes health hazards. Fugitive dust and heavy metal contamination in the ground water are the major problems for the local masses. Like any light weight material dry Fly ash can become air borne. To prevent it from blowing during handling, utilities take precautions such as adding water or thoroughly mixing it with water and transporting it as slurry. Whenever the material is shipped offsite, truck or rail cars are covered to prevent the ash from escaping. When evaluating potential health risks from FA particles or constituents, researchers assess irritation in eyes (watering and redness), skin allergy and respiratory disorders (coughing & sneezing). Repeated inhalation of FA dust containing crystalline silica has been diagnosed as the cause of bronchitis, silicosis, and in adverse cases can also cause lung cancer. Inhalation of high levels of FA dust may result in severe inflammation of the small airways of the lung and asthma-like symptoms.

Skin contact is generally limited to thermal power plant workers and those who produce cement, concrete, building material or some ash based products. Based on experience of those who works closely with it, adverse health effects from skin contact with Fly ash appears to be extremely unlikely. Many studies have examined the toxic effects on various animals through ingesting Fly ash constituents and none has suggested associated health problems. Some tests have shown slightly elevated level of some heavy metals in blood and various organs, while others have found no increase. None of the tests have revealed any damage that would suggest an increased risk of developing health problems from plausible exposure level.

Huge amount of fly ash are generated as solid waste material from thermal power stations. These fly ash get deposited on soil over a large area around thermal power stations.

CHAPTER 3

METHODS AND MATERIALS

SAMPLE COLLECTION

LABORATORY STUDY

CHAPTER: 03

METHODS and MATERIALS

3.1 Sample Collection

Water samples from ash pond of National Thermal Power Corporation (NTPC), Kaniha; National Aluminum Corporation Limited (NALCO), Angul; Rourkela Steel Plant (RSP), Rourkela, and IB Thermal Power Station (ITPS), Banharpali, were collected by using acid rinsed polyethylene bottle. One part of the sample was filtered in the field using Whatman membrane filter paper (25 µm). In the filed pH, Electrical conductivity were measured from the non-filtered samples. Concentration of fluoride was measured in the laboratory immediately after collection using Orion Ion Selective Electrode (Fig 3.1).

Pond ashes were also collected from NTPC, Kaniha. NALCO, Angul; RSP, and ITPS, Banharpali in sealed polyethylene packet.

3.2 Laboratory Study

Samples were air dried in the laboratory and powdered -200 mesh for the subsequent study. Mineralogical study was carried out by X-ray diffraction (XRD) using Phillips PW-1710 X-ray deffractometer employing Cu*K*a radiation at 1.2°/minute scanning rate.

Batch leaching study was carried out using a solution of pH 4.2 as per USEPA (1994). Leaching was done at solid to solution ratio of 1:20. Fly ash of 2 gm was mixed with 40 ml solution of pH 4.2 and kept stirring. Serial Batch leaching test was conducted for the period of 1, 2, 4, 8 and 10 days. After each period the samples were filter using Whatman membrane filter paper and concentration of fluoride was measured. After each filtration, the filter paper was washed with additional 40 ml of solution for the next period.

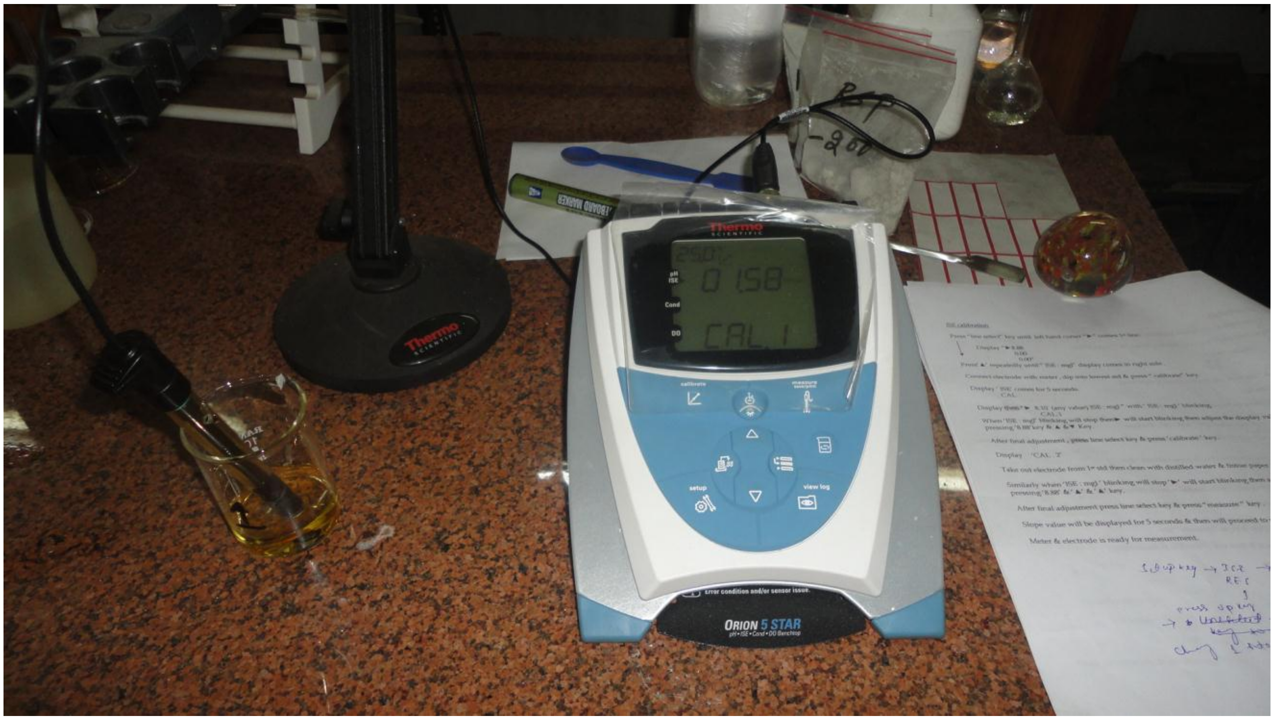

Fig3.1: Determination of Fluoride concentration in the laboratory using Orion Ion Selective Electrode

CHAPTER 4

RESULTS AND DISCUSSION

MINERALOGY OF POND ASH

LEACHING STUDY OF POND ASH

CHAPTER-04
RESULTS AND DISCUSSION

4.1 MINERALOGY OF POND ASH

From the XRD study of pond ash samples, it was confirmed that quartz and mullite are the dominant minerals present (Fig 4.1). Mullite is a rare silicate mineral of post-clay genesis. It can form two stoichiometric forms $3Al_2O_32SiO_2$ or $2Al_2O_3$ SiO_2. Quartz is an essential constituent which is present in fly ash. Quartz is the mineral composed of $\mathbf{SiO_2}$.

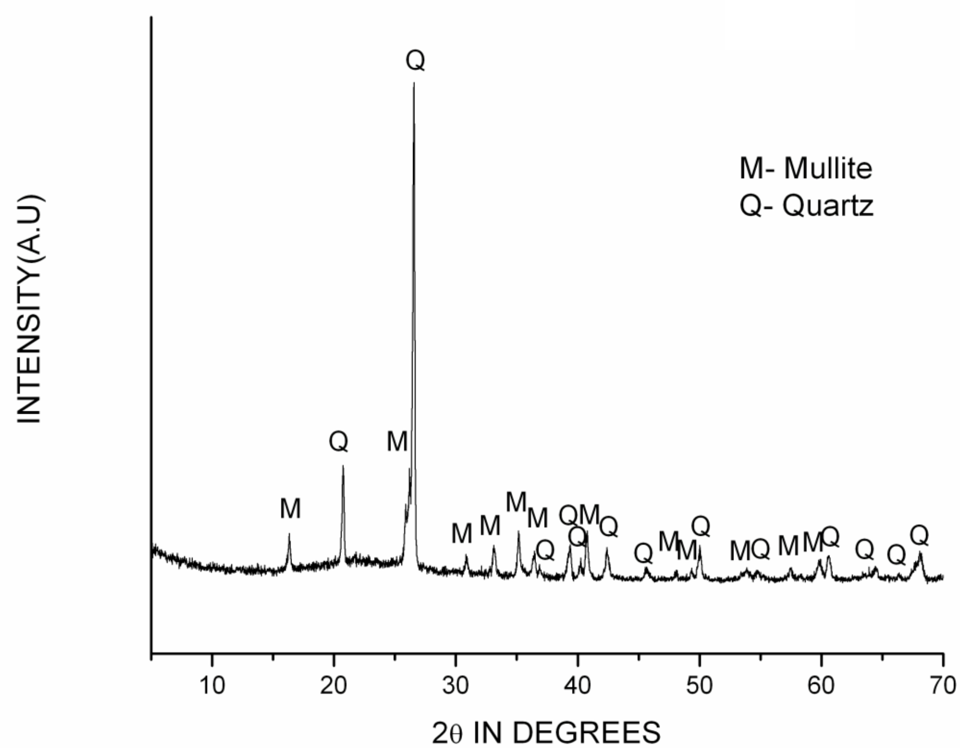

Figure 4.1: XRD pattern of pond ash

4.2 LEACHING STUDY OF POND ASH

4.2.1 pH, EC, Fluoride concentration of ash pond water

pH of NTPC, NALCO, RSP, and ITPS, ranged from 7.26 to 7.98 but pH of ITPS was 6.1 due to slightly acidic nature (Table 4.1). Electrical conductivity (Table 4.1) ranged from 527 to 911 due to different turbidity of water samples. Fluoride concentration ranged from 3.10 to 12.6 (table 4.1). The high concentration of fluoride at ITPC was found.

Table 4.1: water quality parameters from different ash pond water

Location	pH	EC (µS/cm)	F (mg/l)
NALCO	7.56	527	5.93
NTPC	7.98	895	3.10
RSP	7.26	766	3.57
ITPS	6.1	911	12.6
Maximum Permissible Limit	6 to 9	1000	1.5

4.3 LEACHING OF FLUORIDE

Serial leaching of fluoride results are given in Figure (4.2, 4.3) and Table (4.2, 4.3, 4.4, 4.5). The concentrations of fluoride released gradually decreases with increase in contact time. The leaching of fluoride from RSP was maximum. However, fluoride concentration in the leachate is lower than its maximum permissible limit. Cumulative concentration of fluoride (Table 4.2, 4.3, 4.4, 4.5) of RSP is greater than NALCO, ITPC and NTPC respectively. Total fluoride concentration is given in Table 4.6, and ITPS has higher concentration of F than RSP, NALCO, and NTPC.

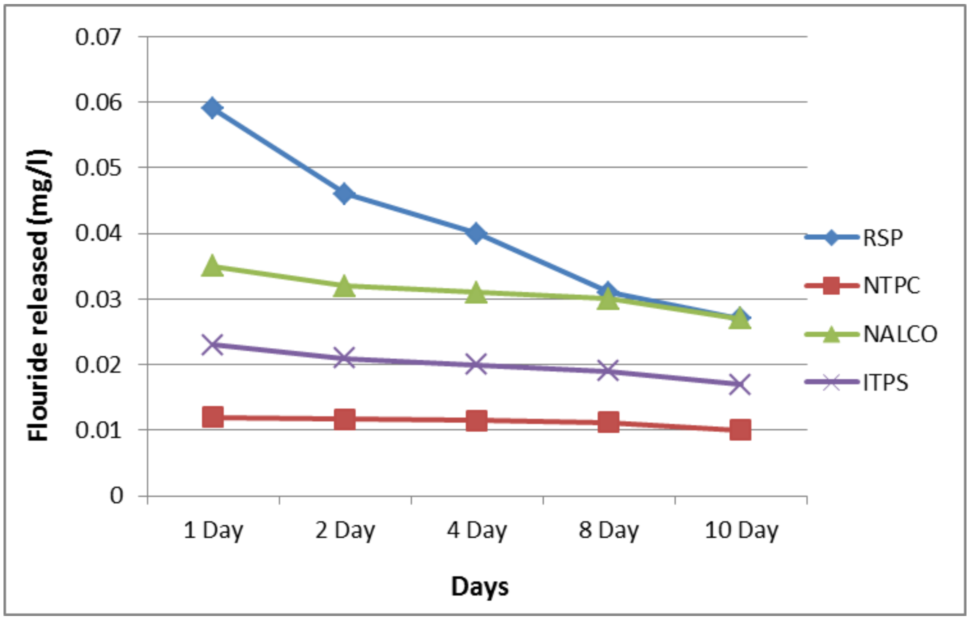

Fig 4.2 : Leaching of Fluoride

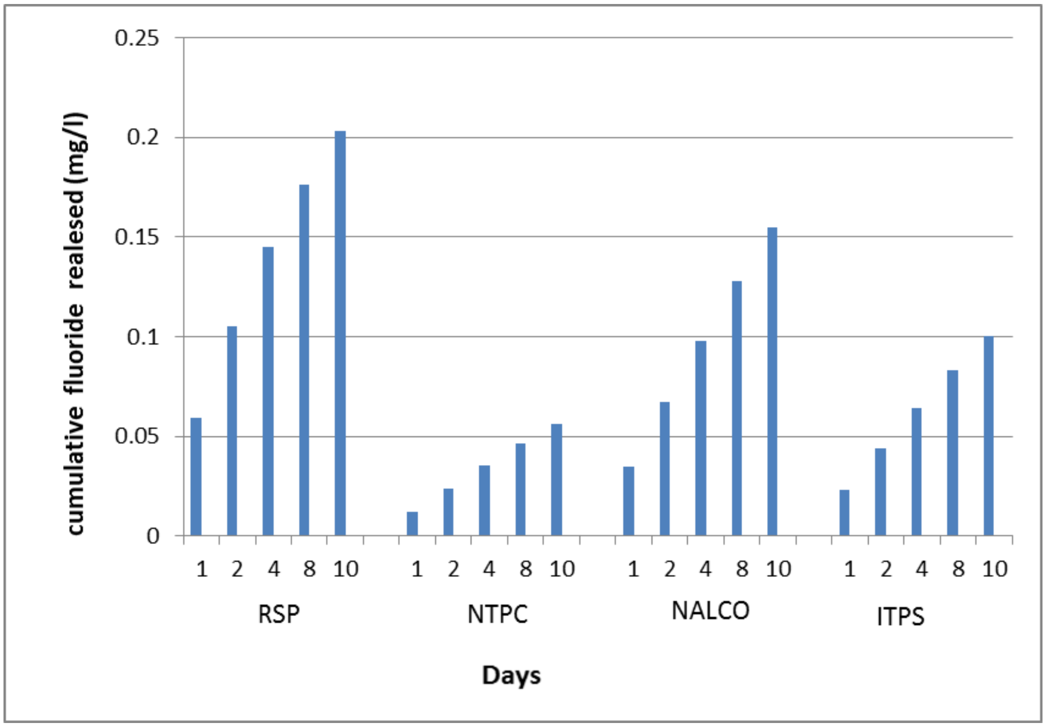

Fig 4.3: Cumulative concentration of Fluoride

Table 4.2: Fluoride released during leaching (RSP)

No of days	Fluoride released (mg/l)	Cumulative fluoride released(mg/l)
1	0.059	0.059
2	0.046	0.105
4	0.040	0.145
8	0.031	0.176
10	0.027	0.203

Table 4.3: Fluoride released during leaching (NTPC)

No of days	Fluoride released (mg/l)	Cumulative fluoride released(mg/l)
1	0.012	0.012
2	0.0117	0.0237
4	0.0115	0.0352
8	0.0112	0.0464
10	0.01	0.0564

Table 4.4: Fluoride released during leaching (NALCO)

No of days	Fluoride released (mg/l)	Cumulative fluoride released(mg/l)
1	0.035	0.035
2	0.032	0.067
4	0.031	0.098
8	0.03	0.128
10	0.027	0.155

Table 4.5: Fluoride released during leaching (ITPS)

No of days	Fluoride released (mg/l)	Cumulative fluoride released(mg/l)
1	0.023	0.023
2	0.021	0.044
4	0.020	0.064
8	0.019	0.083
10	0.017	0.100

Table 4.6: Fluoride concentration in fly ash

sl no	location	fluoride (mg/l)
1	RSP	23.6
2	NTPC	16.4
3	NALCO	15.1
4	ITPS	29.8

CHAPTER 5

CONCLUSION

CHAPTER: 05

CONCLUSION

i. The serial batch leaching study was carried out in different pond ash samples. The concentration of fluoride is higher in ITPS pond ash water which is above permissible limit of fluoride concentration (1.5 mg/l).

ii. The fluoride content of NTPC, NALCO, RSP and ITPS gradually decreased from Day 1 to Day 10 during leaching.

iii. The cumulative fluoride concentrations of NTPC, NALCO, RSP and ITPS increased during Day 1,2,4,8 and 10.

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